The Role of Robust Engineering in the Design of a Scanner Flexure

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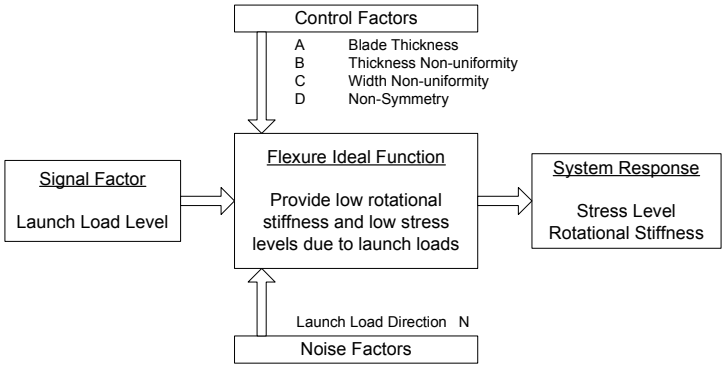
Abstract

Flexures are more reliable than bearings for long-life mechanisms with small magnitude motions. Typically made of metallic materials, a portion of the flexure is thinned dramatically to provide flexibility in the desired degree-of-freedom. When used in space-based remote sensors, the flexure also needs to survive launch-induced loads. The thinned sections act as stress risers in the part, which are susceptible to failure during launch vibration loading.

The flexure in a new infrared remote sensor catastrophically failed during a mass model vibration test. The flexure design was then revised using a L_9 orthogonal array with one noise factor. Two quality characteristics were evaluated, and the critical characteristic, peak stress level, was analyzed using a Smaller-the-Better signal-to-noise (S/N) ratio. A material study was conducted independently of the robust design experiment to validate the material selection for the application.



The design effort was complicated by the constraint to leave the flexure rotational stiffness unchanged while simultaneously improving the load carrying capability. If this requirement was ignored, the Taguchi experiment would have been quite successful, with a 98% improvement in the S/N ratio. However, this improved configuration was not feasible since it significantly affected the rotational stiffness. The primary benefit from the experiment was to identify a path for further design changes, and the relative importance of several control factors.

The design was completed within three days using one-at-a-time iterations of two additional control factors. The final flexure design has a S/N ratio as high as the experiment-recommended configuration without the change in rotational stiffness. Detailed structural analysis using a correlated model shows that all design requirements are satisfied, and the new flexure has been validated by a random vibration test.